

**Comparison of Two Methods of Rearing
Bactrocera dorsalis (Hendel) and
Ceratitis capitata (Wiedemann)
(Diptera: Tephritidae) from Mock Orange
and Coffee in the Laboratory**

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ABSTRACT. Two methods of rearing fruit flies and parasitoids from fruit collected in the field were compared. Infested ripe mock orange, *Murraya paniculata* (L.), fruit were collected from sites in Honolulu and suburbs, and infested ripe coffee, *Coffea arabica* L., were collected from sites in Makaha valley. Fifty fruit were held in the laboratory in individual plastic Ziploc® bags, or fruit were held in groups of 50 per plastic bag. Significantly more ($P < 0.05$ df 34) *Ceratitis capitata* (Wiedemann) were reared from the fruit in groups than from individual fruit. Higher numbers of unemerged pupae were obtained from mock orange and coffee from individual fruit than from fruit groups. The results showed that when given a choice under limited food conditions larvae may migrate from one fruit to another to feed, and thereby improve their chances for survival to maturity. Some larvae of *C. capitata*, which developed in coffee, and *B. dorsalis* which developed in mock orange, showed multiple infestation of these fruits. The implications of this study to tephritid fruit fly ecology are discussed.

KEY WORDS: Insecta, *Ceratitis capitata*, *Bactrocera dorsalis* larval development and migration in coffee and mock orange.

Over 200 fruits and vegetables potentially may be infested by the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), and the oriental fruit fly, *Bactrocera dorsalis* (Hendel). Of the preferred hosts, coffee, *Coffea arabica* L., and mock orange, *Murraya paniculata* (L.), are important key fruit hosts of *C. capitata* in upland and residential areas in Hawaii (Back and Pemberton 1918, Harris and Lee 1986, 1987, Harris and Carey 1989, Harris et al. unpublished). Harris and Lee (1986, 1987) and Wong (1983) reported the kinds and infestation rates of fruits attacked by *B. dorsalis* and *C. capitata*. In those studies fruits were collected in the field and held in the laboratory for fruit fly and parasitoid eclosion. The results were primarily from fruits held in a group, rather than individually. Prokopy et al. (1978) indicated that a pheromone is deposited on the fruit after *C. capitata* oviposits which may discourage other females from ovipositing in the same fruit. Papaj et al. 1990 showed that fewer eggs per clutch are laid by wild *C. capitata* in fruit previously infested with eggs than in uninfested fruit. McDonald and McInnis (1985) showed that the number of eggs laid by *C.*

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capitata was adjusted by females according to the size of the fruit (amount of larval medium) presented to them for oviposition, and that females exhibited other behavior which enhanced the survival potential of their eggs. Prokopy et al. (1978) showed that the pheromone is water soluble, persistent for 6 days, and is equally effective when deposited by wild *C. capitata* or by laboratory reared adults. Their studies were conducted under carefully controlled laboratory conditions, and relatively little information is available on how effective the oviposition deterrent pheromone is under field conditions, where several fruit fly species share limited host fruit resources. We were concerned about whether the presence of an oviposition deterring pheromone would affect infestation of fruits in the field. Therefore, a laboratory study using infested fruits collected in the field was set up to evaluate survival behavior of tephritid fruit flies and their parasitoids. The objective of this study was to evaluate (1) fruit fly and parasitoid recovery from fruits collected in the field and held individually or in groups in the laboratory, and (2) larval behavior contributing to enhancement of survival to the adult stage.

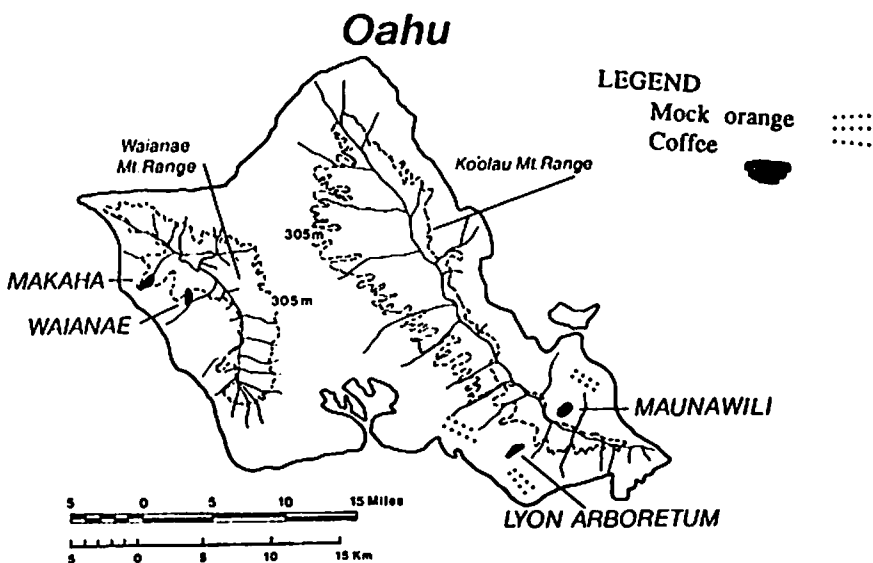


FIGURE 1. Map of Oahu, Hawaii showing sites where coffee and mock orange fruits were collected.

MATERIALS AND METHODS

Development in Coffee. Ripe coffee berries were picked at nineteen locations in the Makaha Valley feral coffee stand. These fruit were weighed individually, divided into groups of 50 berries, and held individually, each

in a separate plastic Ziploc® (Dow Brands Inc., P.O. Box 68511, Indianapolis, IN 46268-0511) bag, or in groups of 50 in one plastic Ziploc bag. The bags were held in the laboratory until the larvae matured, left the fruit, and pupated in the bag. The pupae were removed from the bags, counted and weighed. The pupae were returned to the bags and left until emergence was completed, and the adults were counted.

Development in Mock Orange. Ripe mock orange fruit were obtained from ornamental tree stands in nine urban and suburban locations of Oahu. Mock orange fruit were handled and the data recorded as described above for fruit fly development in coffee.

The tests were conducted in the laboratory at 23-24°C 14% RH, and a 12:12 (L:D) photoperiod. The data were analyzed by t test (Snedecor 1965).

RESULTS AND DISCUSSION

Results are summarized in Table 1. The number of *B. dorsalis* reared from groups of mock orange was higher than the number reared from individual fruit. The number of *C. capitata* reared from mock orange showed the same trend as *B. dorsalis*, but the numbers of flies recovered were low. This indicated that the fruit in groups in contact with one another created a medium which favored survival of a larger number of larvae than was possible with fruit held individually. The number of *C. capitata* reared from coffee fruit groups was significantly higher ($P < 0.05$ df 34) than the numbers reared from individual fruit. In contrast, the numbers of the parasitoid, *Biosteres arisanus* (Sonan), reared from individual coffee fruit was higher than from the groups of coffee fruit. The numbers of *B. arisanus* adults reared from mock orange fruit held in groups was the same as from individual fruit. *C. capitata* infestation was high in coffee and low in mock orange. *B. dorsalis* were recovered only from mock orange. The percent emergence of flies from groups of fruit was higher than from individual fruit. The higher numbers of unemerged pupae from individual fruit suggest that when larvae are confined to one fruit and the nutrition it provides is inadequate, the fly cannot complete development beyond the pupal stage. When larval migration is possible larval survival is improved. Migratory behavior was motivated by the quantity and quality of the infested fruits. In this study, coffee was utilized more by *C. capitata* than by *B. dorsalis*, and the rate of parasitism by *B. arisanus* was higher in coffee than in mock orange. Mock orange was utilized more by *B. dorsalis*, than by *C. capitata*. The numbers of larvae reared per fruit from individual mock orange and coffee fruit are summarized in Fig. 2. The data showed that most of the fruit of each type were uninfested. Sixty mock orange fruit produced one fly per fruit and four produced two flies per fruit. This rate of egg allocation in mock orange is what might be expected if the oviposition deterring pheromone is effective. Coffee fruit were more heavily infested than mock orange (14 vs 6 flies per kg of fruit). One hundred twenty-four coffee fruit produced one fly per fruit, forty-seven produced two flies per fruit, twenty-six produced three flies per fruit, three produced four flies per fruit and

TABLE 1. Summary of *C. capitata*, *D. dorsalis*, and *B. arisanus* reared from mock orange and coffee fruits held individually or in groups in the laboratory.

Fruit Holding Method	Variables	<i>C. capitata</i>			<i>B. dorsalis</i>			<i>B. arisanus</i>			Unemerged Pupae	Dead Larvae	Total Insects	Fruit Number
		♂	♀	Total	♂	♀	Total	♂	♀	Total				
MOCK ORANGE														
Group (n = 9)		5	3	8	51	25	76 _a	1	2	3	4	0	88	450
	Pupae wt(mg)	8.6	9.0		10.0	17.9	8.0	11.5	8.7					
	STD	(0.001)			(0.002)	(0.025)		(0.002)	(0.001)					
Individual (n = 9)		0	2	2	27	21	48 _b	1	3	4	14	1	65	450
	Pupae wt(mg)	0	8.5		11.1	11.5		4.0	6.0		8.6			
	STD	0	(0.002)		(0.002)	(0.003)		(0.001)	(0.001)		(0.003)			
COFFEE														
Group (n = 18)		83	62	145 _a	0	0	0	47	24	71	106	8	330	950
	Pupae wt(mg)	5.9	6.6		0	0	0	4.5	5.1		3.4			
	STD	(0.002)	(0.003)					(0.001)	(0.001)		(0.001)			
Individual (n = 18)		70	37	104 _b	0	0	0	49	35	84	124	2	317	950
	Pupae wt(mg)	5.6	6.8		0	0	0	4.6	5.3	4.4				
	STD	(0.001)	(0.002)					(0.002)	(0.001)	(0.58)				

STD = Standard deviation from the mean. *C. capitata* Group total fruit flies compared with individual totals between rows followed by a different letter are significantly different by T Test.

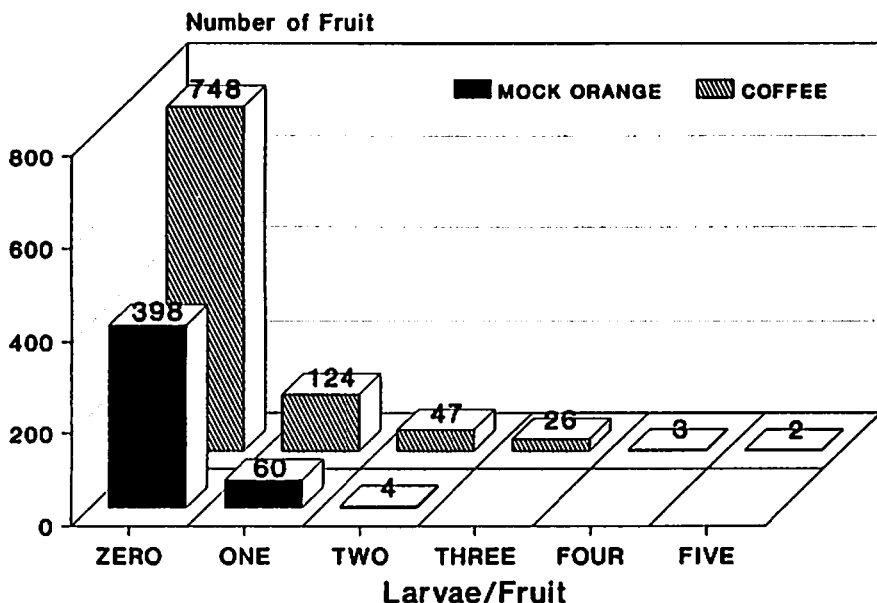


FIGURE 2. Bar graph of the number of larvae of *C. capitata* and *B. dorsalis* found per fruit in mock orange and coffee fruit collections.

two produced five flies per fruit. There was a surplus of uninfested fruit, yet the tephritid females laid no more than one egg in 13% of mock orange and 14% of the coffee fruit collected. These data showed that the oviposition deterring pheromone may not deter repeated oviposition, and hence multiple infestation, of coffee fruit by *C. capitata*. Examination of the data on multiple infestation of individual coffee fruit showed that, in some cases, one female laid 3 or 4 eggs, as indicated by the maturation of all larvae within one or 2 days. In other cases, more than one female laid the 3 or 4 eggs per coffee berry, resulting in emergence of pupae over 4 or 5 days. Adult *C. capitata* and *B. arisanus* sometimes were recovered from the same fruit, as well as and from separate fruit. The work of Harris & Carey (1989) showed that a ripe coffee berry can provide enough food for four *C. capitata* larvae. The fleshy fruit of mock orange can easily provide enough food for more than four *C. capitata* or *B. dorsalis*, or a combination of the two species (Harris et al. unpublished data). Hence, the amount of food available in one fruit exceeds that needed for development of the number of eggs normally laid per fruit. Therefore, the influence of a deterring pheromone in limiting oviposition to one egg per fruit is not important to tephritid fruit fly survival in mock orange and coffee, because each fruit can support up to four larvae, and these fruit may be abundant. The deterrence pheromone may be more important to survival of *Rhagoletis pomonella* (Walsh) (Prokopy 1972), *R. fausta* (Prokopy 1975), and *Dacus oleae* (Gmelin) (Cirio 1971) where the availability of the fruit is limited, or only one larvae per

fruit can be supported. In Hawaii, the wet and dry climates extend the fruiting season and thereby the availability of fruits suitable for oviposition. In wet areas, fruit may decay prematurely. When fruit grow and ripen in clusters and are in contact with one another, larvae can move from one fruit to another, if rotting occurs before a larva reaches maturity. On one occasion in the field, a larva was observed crawling from an exit hole on the surface of a rotting fruit. When no adjacent fruit was found, the larva reentered the rotting fruit although it was unsuitable for survival. These studies suggest that *C. capitata* and *B. dorsalis* respond to variation in local environmental conditions in a manner which enhances their chances for survival.

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